A MAP OF THE DISTRIBUTION OF POPULATION IN SWEDEN: METHOD OF PREPARATION AND GENERAL RESULTS*

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Even today geography, in common with history and the biological sciences and ethnography, tends not infrequently to emphasize the unusual, the scientifically or popularly remarkable, at the expense of the usual—of that which is typical of nature, normal for cultural development, and of practical importance.

NEED OF QUANTITATIVE DATA

Explanation lies partially in the lack of *quantitative* data whereby investigators in their several fields would be in position to discriminate and to give due weight to principal as distinguished from subordinate phenomena. It is a condition that modern research aims to rectify, yet even among present-day scientists the importance of quantitative investigation is far from being recognized. This attitude arises in part from a still general inconclusiveness of treatment; the method of "averages" ought to be regarded with skepticism. What is needed in any field of investigation is a sufficiently full collection of figures susceptible of graphic representation in such a manner that not only averages but enlightening and interesting details may be brought out in their proper quantitative relationships.

Not least is this true of geography. So far it is only in isolated instances that geography has developed suitable methods of expressing graphically on maps such collections of facts as will permit the drawing of general conclusions. The old descriptive geography seldom based its pronouncements on a sure quantitative basis; nor indeed does the new genetic geography which extends its view backwards toward the causes and forwards toward the effects of the facts treated. It appears to be different, however, with the new descriptive geography; and we may hope, so far as source material permits, that it may develop into a genetic-quantitative geography, charting in a clear way its detailed results with regard to chronological as well as spacial relations.

The possibilities of quantitative representation of geographical data are illustrated by the cartographical method described below. It would seem to be applicable not only in the case of distribution of individual objects—

* Karta över befolkningens fördelning i Sverige den 1 januari 1917. Med statsbidrag utgiven av Sten De Geer. 1 : 500,000. 12 plates in atlas, 22½ x 16 inches. Stockholm, [1919] (see note in the *Geogr. Rev.*, Vol. 9, 1920, p. 360). The atlas is accompanied by an explanatory text of 296 pages from which the following article has been prepared.

human beings, dwelling houses, domestic animals—or mass quantities—kinds of land, timber content of forests, economic production—but even in matters of physical geography. The method which is applied to the study of population distribution in Sweden will now be described.

Population Maps

On maps in general, population distribution is represented indirectly and usually very imperfectly by symbols showing the position and size of cities and towns and perhaps smaller centers. Maps showing relative density of population by shading or coloring give a graphic idea of population distribution as a whole provided that the strength of the tint is made directly proportional to the density of population, a desideratum seldom achieved. Furthermore, as a rule such maps show only the average over large areas, such maybe as county divisions or parishes. Details and the actual grouping of the population can be shown only by absolute methods. These methods, however, have been little used for the reason that they have employed different and often arbitrarily chosen symbols and thus are not readily intelligible.

There are four possibilities of symbolism: dots, lines, surface forms, and representation in the solid. In the mapping of relative density the first three methods have been put into use; but the fourth, the three-dimensional representation, has hitherto been neglected and has remained untried. It has been used by the author in his development of the dot method.

Development of the Dot Method: Theory

The *dot method*, as now developed and applied to the map of population distribution in Sweden, offers the possibility of combining a clear representation of situation and mass of population within quite wide limits. The dot method, of which several variants have been worked out, originated in the author's researches on the settlement of Gottland which began in the year 1906 with an unpublished map of the density of habitations on the island calculated by squares of four square kilometers dimension. By this method of procedure the map picture took no cognizance of the run of the parish boundaries. Division of the parishes into small parts proved to be necessary in order that the most characteristic differences in density might appear. Although the contours were angular and lacking in fullness of detail, the map showed clearly the four most important desert zones and several other features of interest.

It would have been easy to make new trials with ever decreasing squares in order to smooth the boundary lines and achieve detail, but the idea was at once carried to its logical conclusion with evolution of the following principle. The *squares ought to be made infinitely small.* They then become mathematical points; and representation is freed from the fallaciousness inevitable in any average calculation. In other words *absolute* method is

substituted for *relative* method. According to this, habitations should be represented on the map as small dots, one for each house, properly located.

It proved impossible, however, to make such a map of Gottland with the help of existing maps, since even the topographic sheets of the Swedish General Staff map (scale 1 : 100,000) do not give the entire number of houses especially in the more densely populated places. On the other hand information as to the total number of persons in the various parishes is readily accessible in the publications of the Statistiska Centralbyrån, Stockholm. Hence it was decided to use the number of persons in the parish as the quantitative element, the location of dwellings on the map determining the geographical position of the quantity, i.e. its more detailed distribution within the parish. From such sources there was constructed in 1908 a dot map of the distribution of population in Gottland.[1]

Distribution by Persons Versus Distribution by Habitations

As a factor contributing towards the geographical landscape, habitations are unquestionably more important than inhabitants; though, on the other hand, inhabitants mean more economically and are significant as active agents, changing the aspect of the landscape including the habitations. But both habitations and inhabitants are closely related genetically and practically; so that, considered in the large, the two factors tend to show the same distributory relation.

As has been said above, the simplest and most correct principle for construction of a house map or a population map is one dot for one object—for one house or one person. People, however, are mobile, and in the most refined analysis this should be taken into consideration; that is the number of persons for a given place should be multiplied by the percentage of time they spend in that place. The relation expressed might have reference to seasonal change—person-months; thus might be depicted the reindeer-keeping nomads, peoples practicing transhumance, summer migration of the city population, movement of fisher folk. Or the relation might be person-hours, having reference to daily movement, as in the case of large cities where the population flows in and out to and from the central working district. Inclusion of the time element, however, is limited by lack of statistical data.

Choice and Size of Dot Units

If the scale of the map is small it may be desirable or indeed necessary to let every dot indicate two or more objects. The essence of the method, however, is that *all the dots are of the same size and value*, that is to say they constitute units of a fixed quantitative value. In the map of Gottland (1908) on the scale 1 : 300,000 each dot represented 10 persons, a relation that may be most briefly expressed by saying that the *ten dot* is used. In

[1] *Ymer*, 1908, p. 240 and chart 4 facing p. 252.

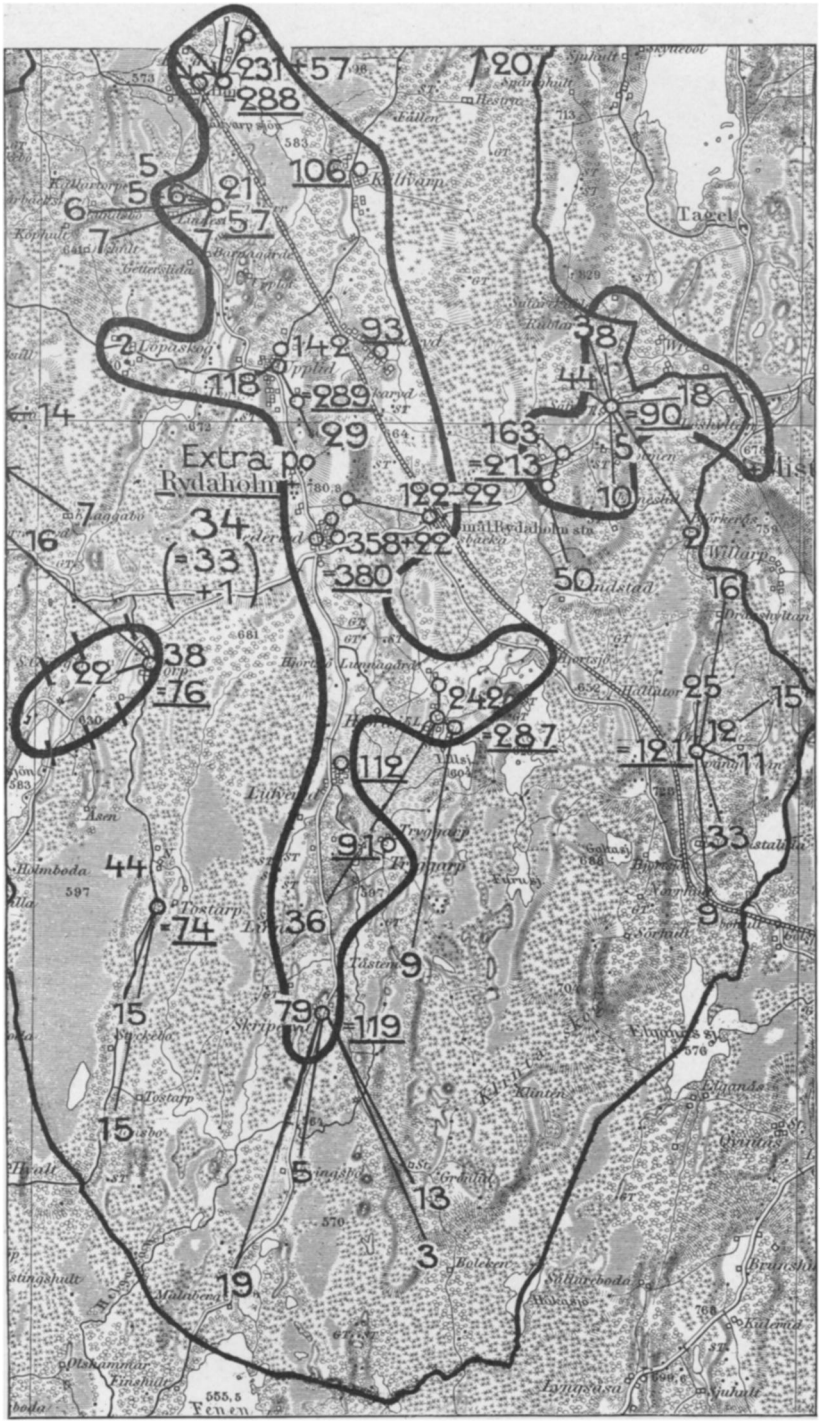

FIG. 1—Rydsholm parish in Småland, southern Sweden, showing how the inhabitants are localized on a map on the scale of 1 : 100,000 and how the numbers are added up to hundreds for representation by dots. The most extensively cultivated parts of the parish are inclosed with a heavy black line.

1914 the author published a map of the world [2] on the mean scale 1 : 80,000,000 with unit dot for 1,000,000 inhabitants; whence it may be seen that dot charts are in no wise restricted to large scales or low dot values.

In addition to the question of scale the choice of dot value depends on the nature of the distribution and its density within the area in question and on the purposes for which the map is destined. The dots should be larger on wall maps and smaller in proportion as the map is to be viewed at closer range and in harmony with other features of the drawing, thickness of lines, and amount of detail.

The individual dot on the dot map should preferably be drawn on the ratio between the natural size of the object and the fraction of the map scale. On the smaller map scales, however, one must be satisfied with having the dots enlarged symbols of the object represented. For comparison between different maps it would be an advantage if the amount of this enlargement could be fixed, either in terms of the actual size of the object in relation to the map scale or to a uniform measure expressed in millimeters or square millimeters. In 1908 the latter method was suggested by the author as it would more easily lead to uniformity. Thus the red unit dots for Gottland were given a diameter of exactly 1 millimeter, corresponding to a surface of 0.79 square millimeter, instead of a surface of 1 square millimeter and a diameter of 1.13 millimeters. The only large city here is Visby, and this was represented by a rectangular symbol measured in even millimeters.

Use of Three-Dimensional Symbols: The Sphere

The problem with reference to the population map of the whole of Sweden proved, however, to be very different since the cities here were to be drawn as large spheres side by side with the unit dots. It was found best then to calculate on a basis of unit volume, the unit dots representing the unit of volume. The most suitable unit proved to be the cubic millimeter with radius of 0.57 millimeter and dot diameter of 1.15 millimeters.

The unit dots are considered as small spheres and ought to be shaded as such to produce the right volume impression, i.e. mass effect, in relation to the variously sized spheres representing the larger cities. Practically, however, this is difficult of achievement. A possibility would be to use a circle filled in with solid color save for a round white dot in the northwest quadrant, but the expense involved in this case has made impracticable any such application of the three-dimensional method of illustration. The unit spheres have been colored solidly (black), and they must be pictured as globes by an effort of the imagination. This modification of symbolism, however, carries with it one advantage, namely, that the unit dots stand out more prominently, in fact as prominently as possible in respect of their size. Viewed from a distance this is a particular advantage, and it is indeed

[2] Sten De Geer: Oceanernas trafiklinjer, Medd. från Handelskammaren i Karlstad, 1914.

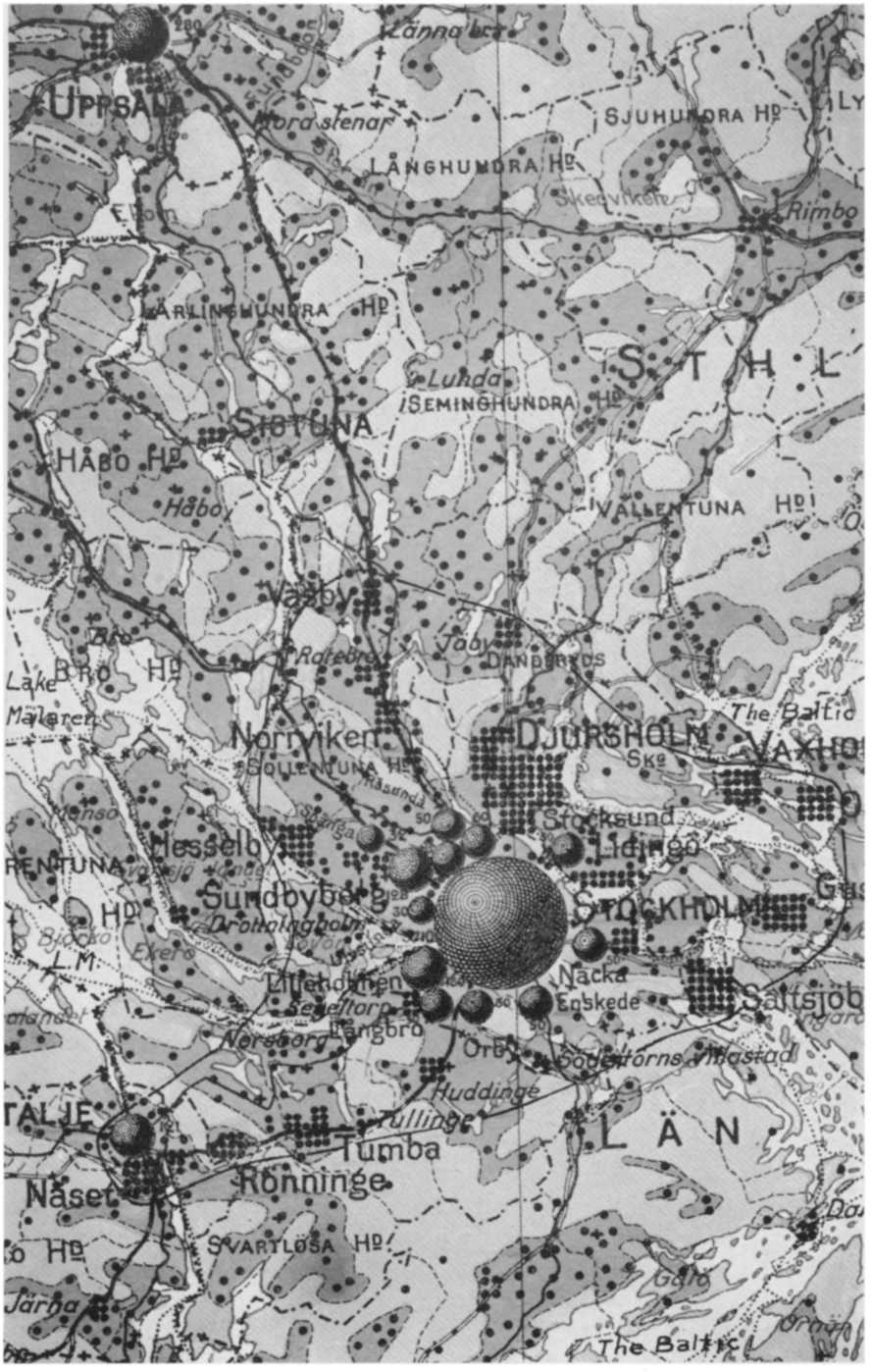

FIG. 2—Stockholm and district from the population map of Sweden, scale 1 : 500,000. Each dot represents 100 persons. The figures by the spheres indicate the number of dots comprised therein. On the original map cultivated areas are shown in yellow (here the darker shade of grey); communications, administrative boundaries; and names in red (here black); water in blue. A thin black line defines the area of the suburbs of Stockholm. The large sphere represents 371,000 inhabitants, the 13 suburban spheres 85,600, and the 30 dot nets 30,400 inhabitants, making a total of 487,000 (in 1917) as the population of Greater Stockholm.

a question whether the practical gain as a whole does not to a considerable extent overbalance the theoretical loss.

It is an indispensable requirement that any population map, as any other cartographical expression of mass or density, should be clear and unequivocal, that is that there should be strictly proportional grading of symbols in respect of magnitude or strength of color or the product of magnitude and color strength.

For the population map of Sweden an absolute method was used in which mass was represented not by color strength but only by size. The dot method used for the map of Gottland was developed to include the larger cities by spheres and spherical shading. Under this plan the greater part of the population has been depicted by means of 100-unit spheres which, however, for technical reasons already mentioned have not been shaded, the shading being confined to the spheres representing the larger cities. The 100-unit dots indicate villages, fishing places, industrial centers, and trade centers and cities proper of not more than 5,000 inhabitants. Unit dots in fact have been used wherever space permitted on account of their greater degree of clearness and of the ease with which the number of inhabitants could be determined by counting the dots, which latter is an easier operation than the computation necessary in the case of the spheres.

Arrangement of Dots

By this means larger and smaller groups, sometimes with as many as 50 dots, have come to indicate a certain densely populated place, or a townlike community, while other groups of dots indicate villages or other agricultural settlements. For this reason the author has further elaborated his method evolved in 1908 by the arrangement of dots into squares, rectangles, or other figures closely corresponding with the actual surficial extent of the settlement. By regularly arranged rows of dots the densely populated places of urban character are distinguished from the irregularly massed dots of the rural communities. Undoubtedly inconsistencies and perhaps even mistakes occur in the working out of this distinction, but it is admittedly a gain to the interpretative quality of the map.

The Dot Net

A row of regularly arranged dots comprises dots of 1.15 millimeters diameter separated by spaces of 0.1 millimeter; thus four dots in a row occupy a space of 4.90 millimeters, or practically 5 millimeters, and this has served as a standard and control in the drawing of what may be termed the *dot net.* On the population map of Sweden the regular groups of dots are built up along east-and-west or north-and-south lines, a contrast in this respect with the Gottland map whereon they were orientated according to the longitudinal axis of the community. The orientated dot nets make the difference between agricultural and industrial population stand out clearly.

Limits of Use of Dot Net

Construction of the population map includes among its tenets that "a dot shall fall entirely within its own parish." But it is evident that the dot net which calls for an unduly large area may fall partially over bordering parishes. When this disadvantage becomes too great, that is in general about the limit of 5,000 inhabitants, the larger spheres are used instead. Thus the Stockholm sphere has a radius of 8.9 millimeters corresponding to 371,000 inhabitants, while a circle of the area of the unit dots would have a radius of 34.4 millimeters, and similarly a dot net of 3,710 dots would cover a square of 75 millimeters side. As has been pointed out, the quantitative value of the spheres is not so readily estimated; hence, to facilitate comparison, the value of the sphere expressed in units is indicated by figures placed within or by the side of the sphere; thus by the sphere for Stockholm is the figure 3,710.

As was said above, the upper limit for the use of the dot net is round about 5,000 inhabitants. Some regional trade centers with a somewhat smaller population have, however, been given the sphere symbol; while, on the other hand, a few mining and industrial centers with a larger number of inhabitants have been shown by dot nets for the sake of consistency. The lower limit for use of the dot net may be thought of as about 1,000 inhabitants, a figure the author arrived at some years ago as a reasonable lower limit of urban settlement in the Scandinavian countries. Work on the dot map, however, has shown that this limit cannot be maintained in the representation of population density. To be sure, the urban character of places disappears at about this value or perhaps even above it; but a smaller agglomeration may yet be sufficiently densely populated and, unlike the agricultural village, may function without direct dependence on the immediate surroundings so that it is desirable to distinguish it from the ordinary rural community. The lower limit of the dot net must therefore be set at a lower figure—four dots, sometimes even two dots or a single dot, may be regarded as representing characteristics pertaining to the dot net. Dot nets of three or four dots, i.e. 300 to 400 inhabitants, may be clearly distinguished on the map from agrarian population groups, and furthermore they are usually identified by name.

The Dot Method in Practice

While the theory of construction of the dot map is simple, the actual working out is relatively complicated. Surprisingly little can be done mechanically even when one is equipped with adequate data of numerical and spacial relations.

Processes of Construction

Whether the basis of distribution is made from the number of dwellings counted on the map or the number of inhabitants according to census

statistics, the work involves two processes. First comes a trial gathering of the smaller settlements into groups of 100 inhabitants or the number of farms corresponding to that amount; while, on the other hand, the larger settlements, towns and cities, are divided up into parts corresponding with the number of dot units (total numerical values being rounded off to even hundreds). The second process is the careful determination of the position of the dots on the map, whether dot nets or single dots.

In the case of the dot nets the choice lies between a possible square arrangement or a form accordant with the areal extent of the place or the available space on the map.

Rules for Placing Dots

Three rules have been drawn up for guidance in the placing of single dots representing groups of isolated houses or small hamlets. First, the dot should be set directly over that place which has more than 50 inhabitants, i.e. more than half the total number represented. Secondly, it should be placed near the center of gravity for the group as such. Thirdly, its position should be determined with due regard to circumstances of density and position of the neighboring groups and indeed to the distribution in the parish as a whole. Near parish boundaries consideration must also be given to dots of the bordering parishes. Thus, for instance, two adjacent border villages of 50 inhabitants should not be represented by two dots but by a single dot. If a dominating settlement is lacking, then the position of the largest existing habitation is to be taken as the position for the dot; but the smaller it is, the more regard must be paid to centralizing the position in relation to the other habitations of the group. As may easily be seen, the three rules are at constant variance with one another; in compromising between them geographical judgment must be brought to bear upon the problem, and hence no fixed rules can be laid down.

In choosing positions for the dots the novice strives more or less unconsciously for an even spacing in an effort to balance mistakes in grouping. But when one becomes accustomed to the work or is in possession of a fuller collection of facts or has a greater knowledge of the character of the region in question, one is particularly on the lookout to depict the actually existing contrasts, aggregations of dots as well as wide empty spaces. Only exceptionally and after long familiarity can the most telling picture of the distribution of population in a large parish be secured without rearrangement and often complete redistribution for the entire parish.

Experience has shown that geographical judgment and care have in fact greater influence upon the correctness of the dot picture than differences between the methods of procedure in the proportioning of the dots.

Habitation Density in Relation to Character of Settlement

The distribution of population which has been represented by means of dots and large spheres constitutes the most important geographical feature

of the map, the further content of which has been selected with regard to its causal connection with the population factor. Most closely connected with population distribution is the distribution of improved land, the two factors making reciprocal demands upon each other.

Areas of dense habitation in general represent the cultivated and settled country. Experience with the population map has shown that the settled country can largely be defined by generalization of the facts presented by the dots. This has been confirmed as a result of two different and for the most part independent investigations, one of the population and the other of the extension of improved land.

Map of Relative Population Density

The problem of representing the various degrees of habitation density may seem identical with the task of constructing a map of relative population density (free from the limitations imposed by administrative and other artificial boundaries) on the basis of the absolute dot map. Heretofore, for lack of formulated method in treating a sufficiently large collection of data in a manner at once thorough and detailed, the selection of grades of population density has either been arbitrary or has been based on too generalized criteria, with consequent sacrifice of actually existing and typical variations to averages and thus to the detriment of the geographical quality of the map.

There are two kinds of objective method for the determination of relative density on an absolute dot map. Curves showing dot density may be interpolated mathematically between the dots, or else by taking into consideration geographical, natural, or cultural boundaries one may endeavor to draw rational limits of dot density. Both methods have been tested, and both in fact have been used on the population map.

Heretofore it has been the practice to distinguish a large number of grades of population density. Through detailed study of the actual grouping of population this has been proved untenable. In respect of the population density of Sweden, at most five grades of density can be recognized: uninhabited country; scattered settlement, thin settlement, dense settlement, urban settlement. In general, however, the scattered and thin settlement may be thought of as consisting entirely of small densely settled spots scattered over wide stretches of uninhabited land. The three essential degrees of density in this case would be: uninhabited land, dense settlement, urban settlement.

On the population map of Sweden the area of connected dense settlement has been shown by deep yellow color: this together with the black dots outside of it should be regarded as *inhabited Sweden*. It constitutes a complex system of largely cultivated surface with a population density of from 50 to 100 inhabitants per square kilometer. As the forest tracts here are abstracted from the area under scattered and thin population, so the

ground under cultivation should be separated from the more densely populated areas of industrial settlement. With this, then, would disappear the difference between the apparently well delineated density grade of dense settlement and urban settlement. Inhabited Sweden would then be considered as composed of a very large number of small areas having a population density of about 1,000 people per square kilometer and having approximately the extent shown by the dots and larger spheres on the map. The entire concept of population density is to a high degree relative, being dependent upon the dimensions of the areas to which reference is made. By the refinement suggested above progress is made from thinking in relative measures ("20 inhabitants to the square kilometer") to absolute numbers ("a population density tract with 2,000 inhabitants").

It is directly apparent from the map that, as far as large tracts are concerned, agriculture in Sweden always creates greater average population density than country industry has hitherto been able to accomplish. Where under exceptional circumstances agriculture and industry have developed in the same region, as in the Malmö district, the greatest average density has arisen.

If abstraction is made of all towns and industrial centers, the density grade of rural areas even within densely settled districts does not greatly exceed between 50 and 100 people per square kilometer. Furthermore, this density is undergoing a steady decline that has been in progress since 1865; partly as a consequence of emigration, as in Vermland (north of Lake Venern) for example, and partly because of the revolutionizing of agriculture by means of modern labor-saving methods, as in Scania as a whole. Among the densely peopled regions such areas show a comparatively thin settlement.

The greatest population density among Swedish agricultural areas is in the valleys of northern Sweden, wherein upper Dalecarlia leads with a density of 200 people to the square kilometer. There the old villages remain. The valley people love their homesteads, and, though their numbers have increased and the cultivated area cannot be extended, they have preferred to stay and divide their farms. The yields per square kilometer are now the greatest in Sweden. Forestry and industry also help to counteract an otherwise imminent depopulation in these settlements.

Such is a single instance of the comparative work that may be done on the basis of the population map. It has a practical value in an infinite variety of applications: in questions of readjustment of boundaries of administrative divisions or of social organizations, of the establishment of public or private institutions, of lines of communication, of the stationing of officials, of the selling of goods, of educational propaganda, of organization of traffic in times of peace and mobilization in times of war—in short, in any matter where it is necessary to know the number and grouping of people.

The map of population distribution can and ought to be causal in the

sense of showing, as many-sidedly and clearly as possible, the connection between this distribution and the most important geographical factors which influence or have been influenced by the grouping of population, whether these be natural or the result of man's activity. Nature, as well as the life of the people, is very changeable, and the geographical factors are many. Hence a strict limitation to a few factors becomes necessary for the preservation of clearness and legibility in the map. These are the ends that have been striven for in the working out of the population map of Sweden; though such are the difficulties involved that they are far from having been attained.